Concrete Slab Lifting System

TECHNICAL FIELD OF THE INVENTION

This invention relates to the lifting of pre-cast concrete slabs and has particular application to a method and apparatus for constructing a multi-storey building.

BACKGROUND OF THE INVENTION

A jacking system as developed by the inventor of the present invention, in US 5,644,893, covered a system for constructing multi-storey buildings. The system comprised extendible props (or jacks) being retractable and having cable suspension means. However in practice this system was found to have many problems that stimulated the development of the current system of this application.

The suspension means of the prior art was found to be impractical whereby the connection to the slab below was not workable due to the high jacking point loads involved creating seriously weakened slab portions. Also during use of the system when the jack was disconnected from each floor, there was no means of support for the jack to prevent toppling. There was also no means to redistribute the load from the jack to reduce effective slab loading and push off loading to the floor below.

The jack relied on an extendable mid portion which was inefficient in its operation, expensive to manufacture and difficult to stabilise during use. The system relied on separate parts such as other prop supports and the extendible props(jacks) and only the floor below to provide the means to push from, making the system time consuming and less safe than it should be. Importantly there was no means for coordinated accurate slab/jack position control. Also existing scaffolding systems are time consuming to erect and dismantle and restrict site movement creating a hazard.

OBJECT

It is an object of this invention to provide an improved method of lifting pre-cast concrete slabs and improved apparatus for carrying this out, or one which will at least provide the public with a useful choice.

STATEMENT OF INVENTION

In one aspect, the invention provides a system of lifting and conveying a concrete slab and/or associated works, wherein the slab having an area includes a plurality of apertures therethrough said slab area, the apertures being provided with a respective jack, said jack at least comprising at least one shaft having a portion passing through said aperture and contacting a lower support means, means for connecting said slab to said shaft, the connection means incorporating at least one supporting member connecting the slab to the shaft, each supporting member passing through another said aperture and engaging said slab, and a means for effecting longitudinal travel of said supporting means along said shaft, resulting in the raising or lowering of said slab, position sensors associated with each jack, means for communicating between each jack and one or more main controllers, and means for controlling each jack whereby the jacks are movable in a synchronised manner.

Preferably the jack includes trailing restraint means being adapted to provide restraint and or stability for the jack once it has climbed or the jack has been disconnected from the slab.

Preferably each aperture therein containing the supporting member is provided in co-operation with the position of the shaft, and henceforth the aperture through which it passes.

Preferably, said lower supporting means includes a supporting strut supporting the shaft from the floor below.

Preferably, said lower supporting means includes a back prop supporting the floor below the strut.

Preferably each aperture therein containing said shaft is proportionally larger in diameter than said aperture therein containing said supporting member.

Preferably each supporting member engages with the downwardly facing or upper face of the slab.

Preferably each jack has pivoting means such that in use each jack can accommodate displacement of the jack whereby there is a minimum transfer of moment through any tensile members.

Preferably each shaft comprises a pair of columns on either side of a ball screw, the ball screw being supported by a spherical roller bearing mounted in a top plate, thus bridging the columns.

Preferably the supporting member/s are steel rods adapted to connect said hanger assembly to the slab.

Preferably the supporting member/s are provided with a respective sleeve.

Preferably the connection means comprises a hanger assembly in co-operation with at least one supporting member.

Preferably the supporting member/s are provided with bearing plates on the underside of the slab, and connected by corresponding bearing plates and fasteners to the hanger assembly.

Preferably the hanger assembly is supported for movement along said shaft, and more preferably the hanger assembly is pivotally supported at a point of rotation at some point along the central axis of the ball screw.

Preferably during climbing, the ball screw will turn downwards in the opposite direction from when it is lifting a slab.

Preferably during climbing the hanger acts in compression and during lifting of each slab, the hanger is in tension.

Preferably during climbing the ball screw acts in tension while during lifting the ball screw acts in compression.

Preferably the means for communicating between each jack includes a wire and wireless means.

Preferably a micro processor or computer or PLC or in combination, is connected via an electric motor to each jack such that synchronised position control is achieved for all the jacks.

Preferably each jack includes a screw jack driven by the electric or hydraulic motor which is controlled by a variable speed drive.

Preferably the system includes a scaffolding means, said scaffolding means adapted to associate with and accompany the concrete slab, wherein said scaffolding means comprises a platform, said platform adapted to engage with a shaft, said platform adapted to allow a number of persons to stand thereon; said shaft therein passing through a guiding means, said guiding means connected to a material to be lifted; a connection means therein adapted to connect the shaft with the material to be lifted.

In another aspect, the invention provides a method of lifting a concrete slab and associated works, wherein there is provided a concrete slab having an area having a plurality of apertures therethrough, a number of said apertures provided with a respective jack, said jack at least comprising at least one shaft having a portion passing through said aperture and contacting a lower support means, means for connecting said slab to said shaft, the connection means incorporating at least one supporting member connecting the slab to the shaft, each supporting member passing through another said aperture and engaging said slab, and a means for effecting longitudinal travel of said supporting means along said shaft, otherwise resulting in the raising or lowering of said slab, position sensors associated with each jack, means for communicating between each jack and one or more main controllers, and means for controlling each jack wherein the method includes the following steps of:

- connecting at least one jack to a slab;
- connecting communication means to at least one jack;
- connecting at least one controller to the jack via the communication means;

- activating the control means whereby each jack is preloaded followed by
- further activating the control means to each jack in a co-ordinated or synchronised manner whereby the slab is raised/lowered by a specific amount.

In yet another aspect, the invention provides a jack for lifting a concrete slab, the jack including : a shaft and ball screw, a drive assembly, a hanger assembly, a support device wherein the drive assembly drives the ball screw to raise the shaft with respect to the hanger assembly such that the jack has climbed the support device supports the shaft to prevent toppling and provide stability.

Preferably the drive assembly further drives the ball screw to raise the hanger assembly with respect to the shaft such that in use the jack has lifted a slab,

Preferably the support device includes a trailing restraint member being arranged with the shaft whereby the trailing restraint member is removably located and connected within the shaft such that in use it can be fully extended from the shaft when the jack has climbed.

Preferably a strut member is linked to the shaft such that when the jack is climbed, the strut can be raised with the jack to the next floor, to provide support for the jack to the floor below.

Preferably the strut is provided with a removable foot member, to redistribute any strut loading through the slab in the floor below the jack.

Preferably the jack includes a controller located at one end of the shaft whereby the position of the hanger can be precisely controlled.

Alternatively the jack does not include a controller.

Preferably the controller is a micro processor or PLC or computer.

Preferably each jack has pivoting means such that in use each jack can accommodate displacement of the jack whereby there is a minimum transfer of moment.

Preferably a back prop can be used to support the floor directly below the strut such that at least two floors below each jack, can be used to provide support.

Preferably the back prop is provided with a removable foot member, to redistribute any prop loading through the slab in the floor below the strut.

In yet another aspect, the invention provides a method of lifting a concrete slab using at least one jack, each jack including: at least one shaft and ball screw, a drive assembly, a hanger assembly, a support device wherein the drive assembly drives the ball screw to raise the hanger assembly with respect to the shaft such that in use the jack has climbed and to raise the shaft to raise/lift a slab, the support device supports the shaft to prevent toppling and provide stability wherein the steps include:

set up – install nuts for the hangers and through-bolt for a jack in an existing ground floor slab or base slab;

a)set up boxing for slab 1 on base 1 (see figure 9, schematic a));

b) pour slab 1;

c)-place jack in place and attach hangers 15;

-remove boxing and relocate to top of slab 1

d),e) pre-load jack and then lift slab 1 with boxing on top with hangers 15 in being in Tension;

f) pour slab 2 on top of slab 1 followed by putting ground floor walls/columns 50. Walls 50 can be placed before pouring slab 2 or afterwards;

g) put new boxing for slab 3;

h) attach strut 32 to base of jack 2 on ground or base slab with foot;

i)-l) climb jack up to next level (first floor) without moving any slabs leaving strut in place from ground to jack (hangers in compression while ball screw in tension); trailing restraint automatically slidably drops down from inside each jack to extend to floor directly below whereby the jack is laterally supported so it will not fall over;

m) n) o) once ground floor columns cured, release hanger from slab 1 to be under slab 2;restablish hangers and pre-load and then lift slab 2 to second floor with boxing for slab 3;

p) pour slab 3 and place boxing on top for slab 4; fit columns to first floor under slab 2 before or after this pour; strut still in place with trailing restraint;

q) prepare to climb jack and struts; position back prop 10;

r) connect strut to back-prop and climb jack;

s) finish climbing the jack until strut foot inserted and back prop foot also inserted; strut and back prop are fully extended; trailing restraint automatically follows;

t) prepare for next floor; u) shows trailing restraint in place;

v) lift third floor ie slab 3; w) shows trailing restraint in place;

x) y)walls 50 put in and pour slab 4 and climb/raise jack and strut and back prop whereby back prop is in the first floor

Alternatively -set up – install nuts for the hangers and through-bolt for a jack in a ground floor slab or base slab;

-set up boxing for slab 1 on base;

-pour slab 1;

-place jack in place and attach hangers;

-remove boxing and relocate to top of slab 1;

-pre-load the jack;

-lift slab 1 with boxing on top with hangers in being in tension;

-pour slab 2 on top of slab 1 followed by putting ground floor walls/columns;

-alternatively the ground floor walls/columns can be erected before the slab 2 pour;

-put new boxing for slab 3;

-attach strut to base of jack on ground or base slab with foot;

-climb jack up to next level (first floor) without moving any slabs leaving strut in place from ground to jack while ball screw in compression;

-slip trailing restraint down to stop jack fall over;

-once ground floor columns cured, release hanger from slab 1 to be under slab 2;restablish hangers and pre-load the jack and then lift slab 2 to second floor with boxing for slab 3;

-pour slab 3 and place boxing on top for slab 4;

-fit columns to first floor under slab 2;

-after releasing hanger and raising hanger to under slab 3;

-boxing for slab 4 placed on slab 3;

-preload and then raise slab 3;

-pour slab 4 and relocate boxing for slab 5;

-put in columns for floor 2 under slab 3;

-climb jack with strut and restraint to floor 2;

-back prop ground floor;

repeat above steps until top of building is reached

In a further aspect, the invention provides a method of lifting a concrete slab using at least one jack, each jack including: a shaft and ball screw, a drive assembly, a hanger assembly, a support device wherein the drive assembly drives the ball screw to raise the hanger assembly with respect to the shaft such that in use when the jack has climbed to raise a slab, the support device supports the shaft to prevent toppling and provide stability wherein the steps include:

-forming boxing for slab;

-pouring concrete in boxing;

-prelifting and then lifting each jack in coordinated amounts;

-providing support to slab;

-climbing each jack while restraint member extends.

Further to said method a strut is provided to support the jack.

Further to the strut, a back prop is provided to support the strut.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of this invention, which should be considered in all its novel aspects, will become apparent from the following description, which is given by way of example only with reference to the accompanying drawings in which:

Figure 1: is a schematic drawing showing the relationship of four jacks, and a computer controller.

Figure 2: illustrates a schematic of the variable speed drive attached to each jack.

Figure 3: is a side elevational view of a multi-storey building being constructed in accordance with an embodiment of this invention.

Figure 4: is a side elevational view of one of the jacks, a first-floor slab being lifted.

Figure 5: is a side elevational view showing an additional slab being connected in preparation for raising.

Figure 6: is a side elevational view showing an additional slab being cast in situ.

Figure 7: is a side elevational view showing the raising of the shaft and associated supported strut.

Figure 8: is a side elevational view showing the shaft and associated support strut having been raised and connected.

Figure 9 are schematic representations of the first part of slab lifting sequence.

Figure 10 are schematic representations of the rest of the slab lifting sequence.

Figure 11 is a schematic representation of a single jack with only one side of the hanger assembly shown in place in two slabs.

Figure 11a is a side view of the typical jack of figure 11.

Figure 12: Is a side elevation of a building, the uppermost slab prepared for the pouring of an additional slab thereon.

Figure 13: Is a side elevation of a building, the slab engagement means having been connected with newly poured slab 24.

Figure 14: Is a side elevation of a building, slab 24 and associated scaffolding having been raised.

Figure 15: Is a side elevation of a building, slab 26 having been poured onto slab 24.

Figure 16: Is a side elevation of a building, for the pouring and subsequent raising of an additional slab 24.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The invention can be understood by reference to Figures 1 to 16 whereby in summary figures 1-10 show the synchronised system, figure 11 shows the jack and figures 12-16 show the scaffolding system. The following numbering sequence for figures 12-16 are to be considered separately, from the other figures.

For simplicity only four jacks 2A - 2D are shown connected to a central computer 5. Each jack is a screw jack driven by an electric motor 3, which is controlled by variable speed drive 4. Typically each motor can be a 0.75-1.5 kW, four pole, 50Hz, flange mounted 400 volts, brake motor. Each motor 3 will be driven by a three phase power supply typically 400 volts at 100 amps. Each motor is controlled by a central computer 5.

The system can provide a synchronised position control through a system controller of a number of motors 3. One control parameter is position synchronisation between all the jacks. This makes use of variable speed control of the individual jack motors, plus a supervisory layer. The implementation of the controls can be:

a) centralised to a unit located off the jacks totally PLC controlled, or
b) decentralised such that each jack is intelligent to a degree and the supervisory overhead is reduced.
c) Or any combination of a) and b) with a suitable system controller.

In either case consideration should be given to the stretch potential of the system. The initial prototype uses a 6 jack system. However, this system can be easily stretched to a 70 jack system. For example to monitor or operate the system requires a MMI for example a screen with a scader™ based software system. Each Jack 2A - 2B is the building block of the system. It is to be considered a self-contained element that is lifted onto site, connected into power and communications and is ready to operate. Consideration should be given to the outdoor and physical nature of a construction site.

The system can be designed so that up to 10 jacks can be daisy chained together; the 10 jacks are to be considered as being connected in series, and not in a ring.

- Jacks can be located 15m apart.
- The cabling (not shown) can be hardwired at one end, with a plug located on the other end or using plugs at both ends. Both wire and or wireless can be utilized.
- Each jack includes at least one set of sockets (power and communications) for daisy chaining a further jack.
- Connections can be weatherproofed to IP65
- The connectors can be used easily with gloved or ungloved hands.

Each jack 2A-2D as shown in figures 3-9 include a shaft 12 and ball screw 9, a drive assembly 8, a hanger assembly 15 and a support device 7. The jack is self climbing jack whereby a slab 20 can be lifted by a hanger assembly 15 and the jack self climbs afterwards. The drive assembly 8 can include a variable speed drive which drives the ball screw 9 by rotating in one direction to raise the jack during self climbing or in the opposite direction to lift a slab with the connected hanger assembly 15, with respect to the shaft such that in use when the jack has climbed to raise a slab, the support device supports the shaft/jack to prevent toppling and provide stability.

The ball screw is located within shaft 12. To lift the salabs a hanger assembly is provided which includes hanger beam 17 strdling the shaft 12. Hanger rods 16 downwardly extend from the hanger beam 17 to extend through the slab to be lifted. Fixing means such as nuts and washers being provided. Located between the base of the hanger assembly 15 and the top of the slab, is a thrust plate 18.

The support device includes a trailing restraint member 7 being arranged with the shaft 12 whereby the trailing restraint member 7 is removably connected to the shaft. For example trailing restraint member can be slidably located within the shaft 12. In use the restraint 7 is slid out downwardly beyond the shaft when the jack climbs. The shaft can be any suitable configuration that allows the trailing restraint to always drop out during the jack climbing and or when each jack is disconnected from the slab. Restraint 7 can be removably connected to the shaft 12 by a rod and nut assembly. After climbing, the restraint can easily self slide back with the shaft while being pulled up as the building height increases. To provide lateral stability to the jack, there can be an overlap portion 21 (see figure 11a) between the member 7, the shaft 12 and between slabs, to further enhance the effectiveness of the stability being provided.

A strut member 32 is linked to the shaft 12 such that when the jack is raised, the strut can be raised with the jack to the next floor, to provide support for that jack.

Each jack 2A-2D can include at least one controller located at one end of the shaft 12 (figure 4) whereby the position of the hanger 15 can be precisely controlled. Alternatively or in combination the jack does not include a separate controller but a central system controller 5 as in figure 1. The controller is a micro processor or PLC or computer with a suitable MMI.

Each jack has pivoting means such that in use each jack can accommodate displacement of the jack whereby there is a minimum transfer of moment. The pivoting means comprises at least two pivoting mechanisms 11 and 13 & 14. One being located centrally under the hanger 15 on top of the ball screw nut 10 when connected to the shaft 12 and a pair of opposing pivoting devices 13 & 14 located at the base of the hangers closest to the slab being lifted or plate 18. The jack includes a back prop 33 to be used to support the floor below the strut 32. Other pivot mechanisms can also be provided to reduce any moment that could be created within each jack.

When climbing the jack we need a device that prevents the bearing on top of the ball screw nut from acting in tension. This can be solved by a plate or other supplementary tensile device such as two opposing tensile devices. The plate 18 can be added to the underside of the nut 10 so that the weight of the jack can be transferred on to the nut from the floor during lifting. This

avoids the bearing on top of the nut acting in tension during climbing. As an alternative to the plate other devices are also possible such as beams or frames.

In lifting a slab, the shaft 12 rests on a lower floor and the rotating ball screw drives the nut upwards. If the nut engages or mets the underside of the top floor slab, it will be raised with the nut. However if the nut is engaged with or is resting on the top floor and the ball screw turns in the opposite direction, the jack will move upwards until the nut is at the bottom of the ball screw. Therefore the direction of rotation of the ball screw determines whether a slab is lifted or the jack itself is self climbed to be ready for the next lift.

The shaft, strut and back props can have removable feet 19 as shown in figure 9 (l)-(o) and figure 10 (s), (t) & (u). Feet 19 are designed and dimensioned to cover any slab aperture and provide adequate strength to spread any jack loading away from the aperture and into the slab.

All local controls, drives, cabling can be mounted onto the jack itself, and as much as possible into a single enclosure. The equipment can be weatherproofed as per required standards such as IP65, and all non-IP65 elements can be enclosed.

The motor 3 can be a 4pole, 1.1kW, flange mounted, brake motor. In another variation the motor can be a servo based motor. The motor is the only non-IP65 element on the jack. The motor can be mounted shaft down. For the position sensors an encoder can be used which is mounted on the motor. The encoder can be physically protected from damage; e.g. being stood on.

Torque monitoring of the motor can be provided. During the initial portion of the lift, after placement through the slab all jacks are driven until a pre-set torque is obtained (or a threshold distance is exceeded). This takes up an initial load; pre-tensioning and saves on time and travel. A percentage of the load being taken by the jacks which can be checked. The jacks can have an overload rating. Although during the course of active lifting it is not envisaged that the jacks will operate in overload.

For the purposes of fault detection, the drive is capable of being halted when a torque threshold or load threshold is exceeded. This is to guard against events like driving into the ends of the

ball screw, jamming of the load being lifted and the like. A load cell can be incorporated into the sensors.

There is a requirement for the lowering of the load. Therefore the gearbox and ball screw can have efficiencies of better than 90%. Regeneration capability is to be included. Optionally if regeneration resistors are integral to the drive, then a rating provided for the lowering ability given the drive is preferably housed in an IP65 enclosure; the lowering requirement will either be a short distance (say 50mm @ 1mm/sec) for final alignment or full lowering of the load (say 4.5m @ 1mm/sec). Alternatively the regeneration resistors can be mounted externally.

The motor can have a brake which can be controlled and the motor torque and or load can be verified before the brake is released. Other inputs to the drive can include:

- Upper limit switch
- Lower limit switch
- Emergency stop

Each of these inputs is to be considered as a set of clean contacts, and when opened the drive is to stop instantly (not drive to a halt). The status of these inputs, especially when tripped, is to be reported to the central controller. The simplest cable installation can be that the communications cable and the input power cable which daisy chain between jacks are strapped together. The effect of electrical noise on the power cable can be minimised such that any degradation in communications performance does not occur. Wireless technology can also be used.

The system controller can include:

1. An enclosure which provides

- a 230V outlet for a computer
- an emergency stop pushbutton. The emergency stop push-button shall disable power to the system.
- A communications link to the laptop

2. A laptop operating a Man Machine Interface (MMI) package, from where the operator will operate the system.

3. Optionally, a PLC controller can be incorporated.

The nature of the MMI is to provide the supervisory and control level. The minimum operator inputs can include:

- set the direction (up/down),
- set the distance to traverse (in mm),
- set any maximum speed (mm/sec) and torque (%) limitations.

The MMI can be laptop based, and running under Windows 95 or NT, or other suitable operating system. During the lift, all torque and position information recorded from the field can be time stamped and recorded to disk. This information can be saved in a tab-delimited fashion, such that it can be read into Microsoft Excel with no further modification.

For each jack, a database of life load / hours run can be automatically maintained. The replacement of a jack can be, due to failure say, should be task largely performed under MMI control with all setting and current position information downloaded across the communication link from the MMI to the drive when it is connected in.

For an out of tolerance condition, the system can be driven to a halt and a warning reported. The information from the field can be presented on the laptop screen such that exceptions are easily visible; something similar to green ... orange... red signal level displays which draw attention to the relevant points only.

Warnings are provided to the operator, indicating the nature of the problem and possible help. The nature of the situation will determine the timeframe in which either the system responds or awaits operator input; e.g. an out of tolerance results in the system being driven to a halt. Error and Warning conditions displayed on the MMI, and logged to file with a time stamp, can include:

- Out of position tolerance, plus an indication of which jacks are in error

- Overload of jacks
- Jack infringing a limit switch; upper or lower
- Jack infringing a torque limit (driven into the end stops say)
- Any drive error or warning that warrants operator attention
- Lost communications with a jack or item of equipment on the communication network.
- The provision of the total current drawn by the system (derived from drives). This may allow reduced speed operation from a supply rated less than that required to lift at full speed.

The positional accuracy between two jacks over the duration of the lift can be 0.5 mm. The lift range is can be 5.5m and the time to traverse this distance is can be a minimum of 60 minutes. For example typically the maximum number of jacks may be 70. Provision can be made for faster traversals, e.g. when driving the jacks unloaded from one end to the other.

The primary task is to lift a slab and or any associated catch screens or formwork or scaffolding, such that the slab is maintained level over the duration of the lift. A simple extension which does have occasional use is the ability to raise a slab onto a defined angle.

Electrical noise suppression can be provided. The ambient temperature range for operation can be 0°C to +50°C. It is expected that the load experienced by each jack will be different. In order to understand how the control system will operate, the following will now describe the use of the above jack on the construction of a multi-storey building with reference to Figures 3-9. This will provide an overview of the mechanical operation of a first type of jack, but the description of the control system in Figures 1 and 2 has been omitted from this 'mechanical description'.

As shown in figure 3, there exists a ground floor slab 5, on to which a concrete slab 20 is formed with a plurality of apertures (not labelled) therethrough. A number of shafts 12 are positioned through said apertures and contacting said ground floor slab 5. Boxing 6 is provided in preparation for the pouring of an additional slab in co-operation with preparation for the lifting of the slab 20, as the following will further explain.

As shown in figures 4, 9 and 10, a gearbox/motor/drive assembly 8 can be axially positioned at the top of each shaft 12 to drive the ball screw 9 to raise or lower a hanger assembly 15 with respect to the shaft 12 and hence raise or lower the slab 20 relative to the lower floor slab 5. The shaft 12 can be any suitable supporting member that enables the trailing restraint to be accommodated therein. For example rectangular hollow section (RHS), tube, hollow box section or a frame.

Once said slab 20 has been raised the required floor to floor height, for example 3 metres, the slab can be then lowered approximately one slab thickness, so as to ensure the final floor to ceiling height does not gain a height of one slab thickness, after each slab is raised.

As figure 5 shows, once the slab 20 has been raised to the desired position, and additional slab 22 poured, a connection means 30 is then disconnected from the slab 20 and re-engaged with uppermost slab 22.

The foot portion 35 can be proportionally sized in relation to the respective aperture through which it passes (aperture 40 in this case), so as to facilitate the retraction of the foot 35 through the corresponding aperture 40. Alternatively the foot can be carried out by hand.

Once retraction and subsequent reengagement of said shaft 12 and re-engagement with, for example, the uppermost slab 22 has been actuated, said slab is then prepared for the pouring of an additional slab 24, for example, by way of boxing 6, the connection means is engaged with newly poured slab 24, and the subsequent raising of said slab 24 (not illustrated).

It should be noted that the present invention allows lifting of the various slabs prior to full curing of the slabs. Once a slab is in position and raised the slab can be connected to the permanent structure by vertical elements such as support structures 50 and stabilise the slab while it fully cures. During this curing stage, it is possible to connect the slab 20 to the remainder of the building. This connection with structural walls or columns of the building may be accomplished by means of connection plates or reinforcing steel extending from both the wall or column and the slab, this reinforcing steel overlapping in a previously formed void. The

connection is then accomplished by filling the void with a hardenable material, such as concrete.

Another method of attaching the slab to the building is to use structural beams which are connected to the wall of the floor below. To explain, a slab is lifted to a position slightly higher than the final floor to ceiling height. Structural beams or plinths are then positioned by any appropriate means for example small electric forklifts, and connected to the various walls. The slab is then lowered and connected to the structural beams or plinths. Such a method of attaching the slab to the building is safer and speedier than conventional methods of construction and allows all work to be carried out on a stable platform.

As shown in figure 7, said retraction of said shaft 12 is accompanied by the raising of strut supports 32, thereby providing effective engagement of jack with, for example, lower slab 22, as shown in figure 8.

During climbing the hanger acts in compression and during lifting of each slab, the hanger is in tension. Also during climbing the ball screw acts in tension while during lifting the ball screw acts in compression. Once the floor has been raised, it is connected to the vertical elements of the permanent structure, this may be accomplished by walls or columns 50 etc. When the integrity of this connection is reached, the floor load is released off the jack and transferred onto the connection joint mounting to the mentioned vertical elements.

The jack can then be 'climbed' through the said apertures and may include the struts and props by way of connection. Experience has shown that when the jack is disconnected from the slab it will have a tendency to fall over, thereby necessitating the innovation of including in the jack, trailing restraints 7 that couple to the lower floors. These are shown in use in figures 9, 10 and 11.

As it will be clear to a person skilled in the art, the above sequence or steps can be further repeated for the number of storeys required in the building. The sequence of events may be summarised as, firstly pour a slab about the prop means, and cure to 22 megapascals (Mpa), prepare for the pouring of the second slab, raise slab and associated preparation means,

disengage connection means from newly raised slab, pour uppermost slab, engage connection means with uppermost, newly poured slab, raise shafts, position support struts, engage struts with corresponding shaft/s, raise uppermost slab, repeat process. It should be noted that since the jack climbs the building with each newly constructed floor, there is no need to remove and re-position scaffolding from floor to floor.

In summary the method can include the following minimal steps of:

- connecting at least one jack to a slab;
- connecting communication means to at least one jack;
- connecting at least one controller to the jack via the communication means;
- activating the control means whereby each jack is preloaded followed by
- further activating the control means whereby the slab is raised/lowered by a specific amount.

As shown in the schematic views of figures 9 and 10 a further series of steps for raising concrete floors. The following steps are labelled to match each schematic a) to y). Schematics k), u) and w) are side views of respective front views of the immediately preceding front views. Some of the steps are:

-set up – install nuts for the hangers and thru bolt for a jack in an existing ground floor slab or base slab;

a)set up boxing for slab 1 on base 1 (see figure 9, schematic a));

b) pour slab 1;

c)-place jack in place and attach hangers 15;

-remove boxing and relocate to top of slab 1

d),e) preload jack and then lift slab 1 with boxing on top with hangers 15 in being in Tension;

f) pour slab 2 on top of slab 1 followed by putting ground floor walls/columns 50. Walls 50 can be placed before pouring slab 2 or afterwards;

g) put new boxing for slab 3;

h) attach strut 32 to base of jack 2 on ground or base slab with foot;

i)-l) climb jack up to next level (first floor) without moving any slabs leaving strut in place from ground to jack (hangers in compression while ball screw in tension); trailing restraint

automatically slidably drops down from inside each jack to extend to floor directly below whereby the jack is laterally supported so it will not fall over;

m) n) o) once ground floor columns cured, release hanger from slab 1 to be under slab 2;restablish hangers and preload and then lift slab 2 to second floor with boxing for slab 3;

p) pour slab 3 and place boxing on top for slab 4; fit columns to first floor under slab 2 before or after this pour; strut still in place with trailing restraint;

q) prepare to climb jack and struts; position back prop 10;

r) connect strut to back prop and climb jack;

s) finish climbing the jack until strut foot inserted and back prop foot also inserted; strut and back prop are fully extended; trailing restraint automatically follows;

t) prepare for next floor; u) shows trailing restraint in place;

v) lift third floor ie slab 3; w) shows trailing restraint in place;

x) y)walls 50 put in and pour slab 4 and climb/raise jack and strut and back prop whereby back prop is in the first floor.

The above main steps of prelifting/preloading, lifting, climbing with trailing restraints, struts and back props are repeated with walls 50 etc and boxing with scaffolding being erected where necessary and or being dragged up as appropriate. For example the boxing or walls 5 can be erected before or after any of the other steps.

The following will now describe the use of the scaffolding means as shown in figures 12-16 wherein the apparatus is adapted for use with for a multi-story building or single strong building being constructed with raisable concrete slabs which can pre-cast or poured on site. Note that the numbering sequence for these figures runs on a separate sequence to that of figures 1-11.

In order to provide greater clarity with respect to the accompanying scaffolding means, the following now details the sequence applied to the construction of a multi-storey building, to which the apparatus of the present invention can be associated:

Alternatively, the scaffolding means can be attached to the concrete slab after being poured. The scaffolding means includes formwork/boxing preparations 6 for each slab, support for workmen, safety components 5, support and means 12 to allow extension of the formwork and

connection means 18 and guiding means 10 and 11 for connecting of the scaffolding means to a slab. The scaffolding means is adapted to fit or be fitted to the edge of a concrete slab.

Firstly, a concrete slab is poured in boxing/formwork about the jack and guiding means 10. For example, in figure 12 the first slab can be formed on the ground 3 or any convenient supporting surface. The slab is cured, and preparations such as boxing/formwork, are made for the pouring of an additional slab on top. The additional slab is poured around connection means 18. The additional slab only and further associated preparation means are then raised. The connection means is then disengaged from newly raised slab, the uppermost slab is poured, and the connection means is engaged with newly poured slab. The process is then repeated.

As shown in figures 12-16, there exists a ground floor slab 20, a first floor slab 22, and boxing 6 in preparation for the pouring of an additional slab 24. Slab 20 is provided with a guiding means 10 outwardly affixed thereto. A shaft 12 is provided through said guiding means, and incorporates a platform 5, said shaft otherwise hanging from slab 22 by way of the outwardly affixed connection means 18.

It will be appreciated that workmen of the construction site will stand on the platform 5, in order to pour said additional slab 24. The platform can include provision for safety. For example for people and/or materials whereby for example guard-rails can be provided or safety curtain can be attached.

As seen in figure 14, it will be appreciated that the additional slab 24 has now been poured, and steps taken to prepare for the raising of the slab 24. Said connection means 18 is disengaged from lower slab 22, and re-engaged with top slab 24. It is noted that the shaft 12 is disengaged with guide means 10 during lifting, and accordingly guide means 11 has been introduced to associate the shaft 12 with slab 22.

Referring now to figure 15, it will be appreciated that upon lifting of uppermost slab 24, the shaft 12 and associated platform 5 will also be raised.

Figure 16 shows the preparation for the pouring and subsequent raising of an additional slab 24. As it will be clear to a person skilled in the art, the above sequence can then be repeated for the number of storeys required for the building.

ADVANTAGES

The present invention provides an inventive method and apparatus for constructing a multi-storey building. The inventive method and apparatus lifts an entire floor slab or sections of a floor slab into position without the need for exterior lifting apparatus such as cranes. There is also no need for repositioning of scaffolding, form-work etc. from one floor to the next since the inventive prop means climb the building as it is constructed ready to lift the next floor slab.

While the present inventive apparatus may be used for any building with at least ground and first floor levels, it is envisaged that the inventive method and apparatus will provide the greatest benefits in large multi-storey buildings with approximately six or more floors.

The control system of this invention enables the controlled lifting of cast concrete floors, without the need for external cranes or the like, as each floor can be cast upon the floor below, and provided with suitable apertures to allow the jacks to be inserted through those apertures, and to effectively climb up the building as the slabs are raised into position, as shown in the overview with respect to Figures 3-8.

The control system has the particular advantage in providing safe, smooth, controlled lifting such that the floor slabs can be raised substantially horizontally, and can be lifted together with any associated catch screens, edge form-work, or other ancillary structure or fittings located on or attached to the floor slab.

The invention lends itself to the construction of floor slabs of various plate sizes, and it is envisaged that a small operation may use six jacks operating in unison, but much larger multi-storey buildings with substantial floor plates may use up to 70 jacks at a time.

The jacks, are robust, and can be readily installed or removed from site to site. These jacks are not extendible thereby eliminating expensive overlapped portions that are difficult to stabilise

and connect together causing both safety concerns and extra expense. They have trailing restraints that enable excellent stability during self climbing and are also configured such that the apertures size and occurrence in the slab are kept to a minimum thereby not compromising safety and slab integrity. The struts and back props are optionally used with the jacks whereby the jacks though desirably more safer with the struts and back props will still be able to lift each a slab. If the back prop was included in the jack with the trailing restraint, the size of the jack would increase thereby creating the need for larger slab apertures. The jack is also configured to enable at least two floors below, to be utilized to share the jacking loads and slab loads whereby during climbing there is an automatic lateral stability being provided to the jack.

The present invention provides an inventive apparatus for use with the construction of a multi-storey building. It will be appreciated that there is no need to reposition scaffolding about the building, as the invention allows the apparatus to effectively climb the building with each additional slab being raised. It will also be appreciated that the present apparatus is easy to assemble and operate.

VARIATIONS

The control system is illustrated as being controlled by a laptop or portable computer, but it is possible that it could be controlled in a number of different ways either using specialist hardware, or off-the-shelf computers, and indeed the system could be controlled from off-site provided there is a suitable connection between the sensors and controllers on the jacks, perhaps via the Internet, to a specified computer. However, for most purposes it is preferred that the controller is on-site, and is available to an operator who can watch the operation of the jacks, as well as monitoring the computer screen and other readouts. In most cases the operator will position the portable computer in a cabin, caravan or the like on the site adjacent the building being constructed, although it is possible that the operator and the control computer could be located on the slab being lifted, although this is less preferable.

Finally, it will be appreciated that various other alterations may be made to the foregoing without departing from the spirit or scope of this invention.

To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

It will be appreciated that various alterations can be made to the foregoing without detracting from the spirit or scope of the invention. For example, the shaft 12 may comprise a substantially vertical, elongate member (or combination of members) of a variety of differing cross-sectional shapes.